



# **NASA Glenn Research Center Overview**

**Presented to the NASA Advisory Counsel**

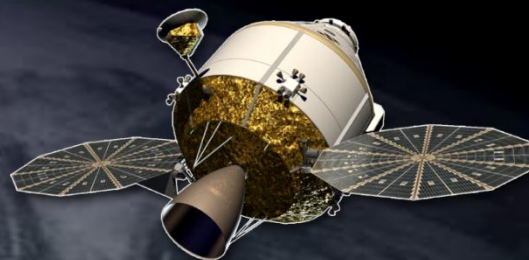
**by**

**Ray Lugo, Center Director**

**May 4, 2011**

# Vision and Mission

- **NASA Vision**: To reach for new heights and reveal the unknown, so that what we do and learn will benefit all humankind
  - **NASA Mission**: Drive advances in science, technology, and exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of the Earth
- **Glenn's Mission**: We drive research, technology, and systems to advance aviation, enable exploration of the universe, and improve life on Earth





# NASA Centers and Installations

- Deep Space Network Facilities:
- Goldstone, in CA Mojave Desert
  - near Madrid, Spain
  - near Canberra, Australia

**Ames Research Center**  
Mountain View, CA

**Glenn Research Center**  
Lewis Field  
Cleveland, OH

**Goddard Space Flight Center**  
Greenbelt, MD

Glenn Research Center  
Plum Brook Station  
Sandusky, OH

Independent Verification  
& Validation Facility  
Fairmont, WV

Goddard Institute for  
Space Studies

**NASA Headquarters**  
Washington, D.C.

Wallops Flight Facility  
Wallops Island, VA

**Langley Research Center**  
Hampton, VA

**Marshall Space Flight Center**  
Huntsville, AL

**Stennis Space Center**  
Stennis Space Center, MS

**Kennedy Space Center**  
Cape Canaveral, FL

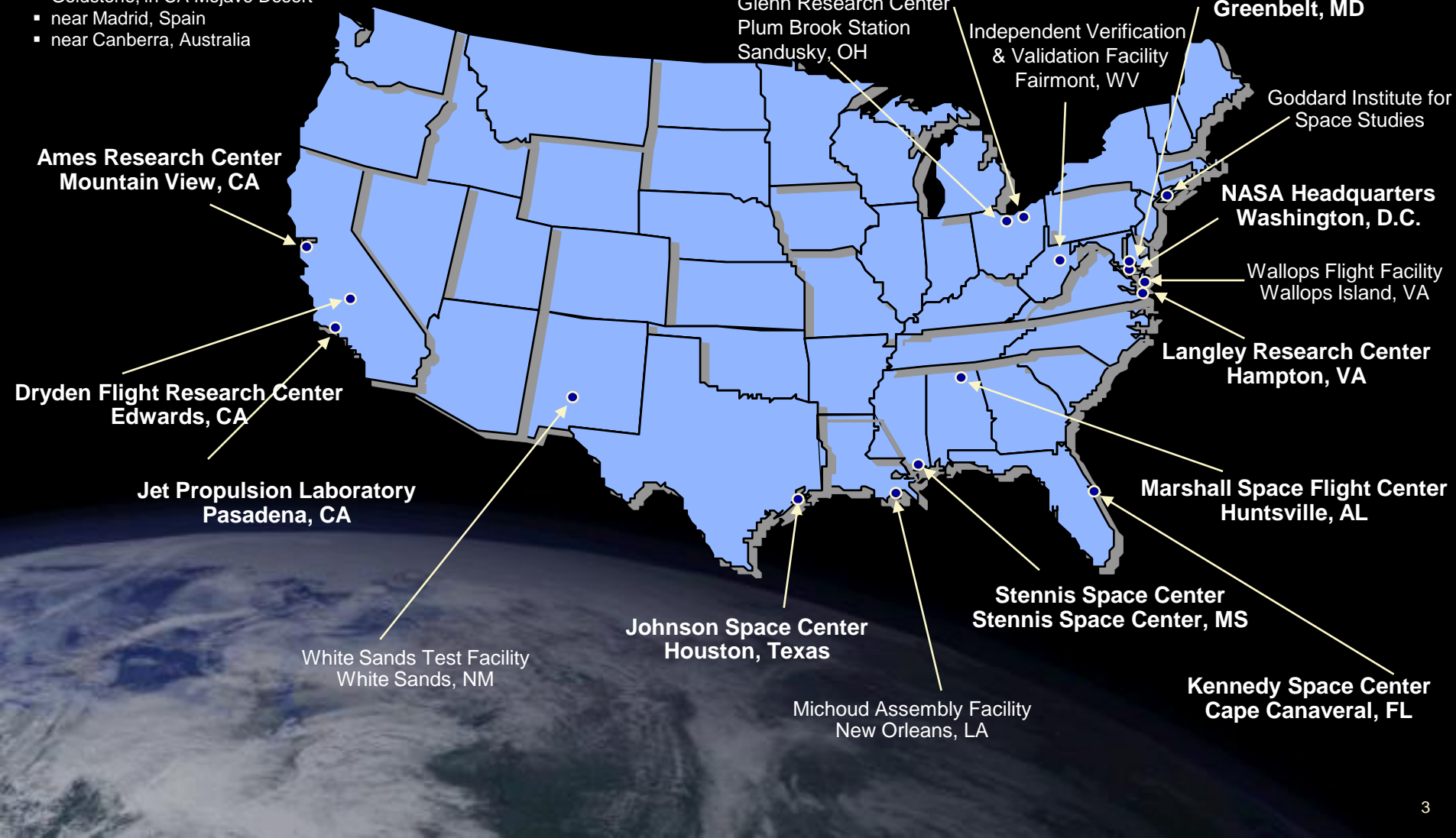
**Johnson Space Center**  
Houston, Texas

Michoud Assembly Facility  
New Orleans, LA

White Sands Test Facility  
White Sands, NM

**Jet Propulsion Laboratory**  
Pasadena, CA

**Dryden Flight Research Center**  
Edwards, CA



# Glenn Research Center



## Lewis Field

(Cleveland)

- 350 acres
- 1646 civil servants and 1719 contractors

## Plum Brook Station Test Site (Sandusky)

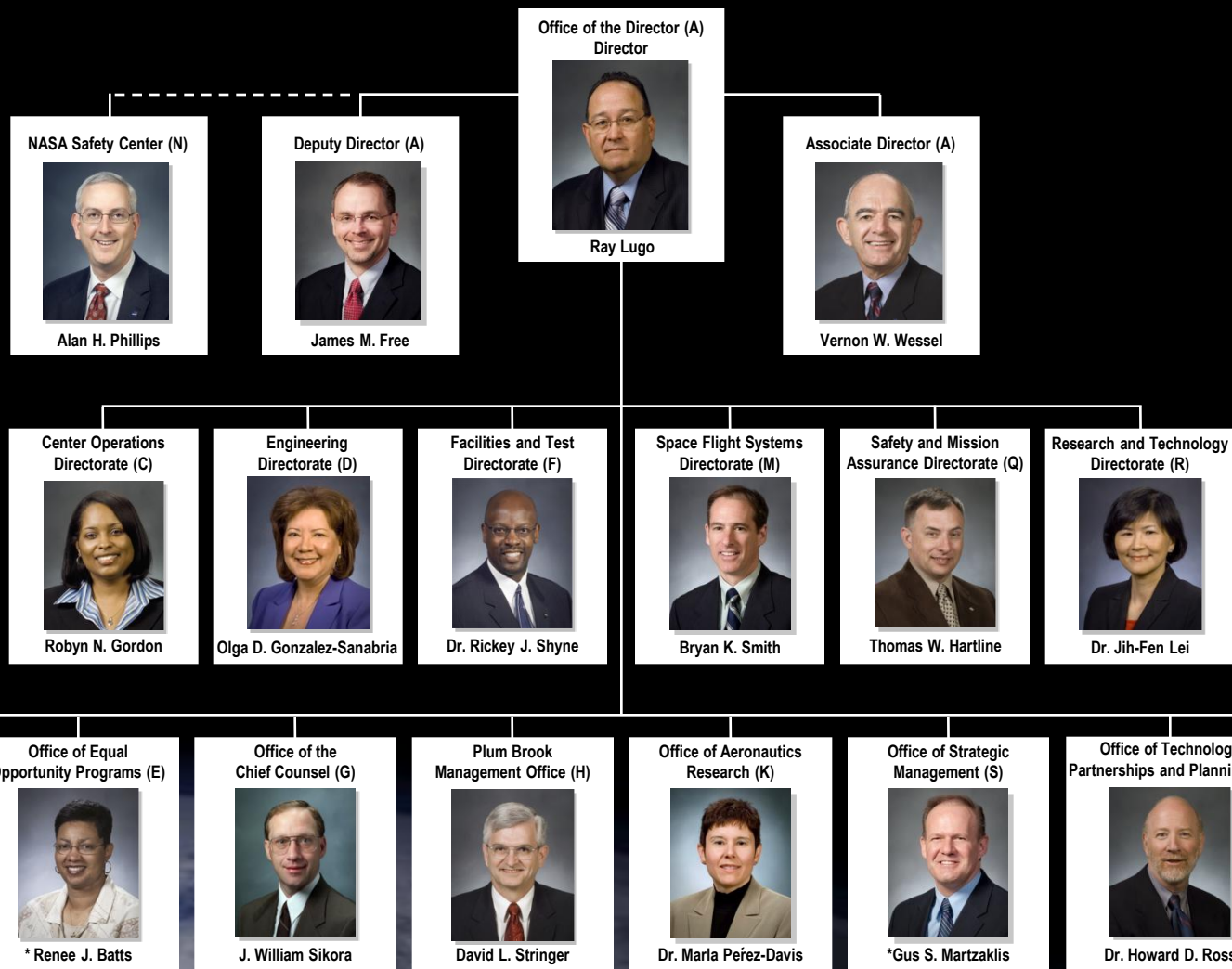
- 6500 acres
- 16 civil servants and 140 contractors



As of April 14, 2011



# NASA Glenn Research Center Senior Management





# **Glenn Research Center Goals**

## **NASA Glenn Strategic Action Plan**

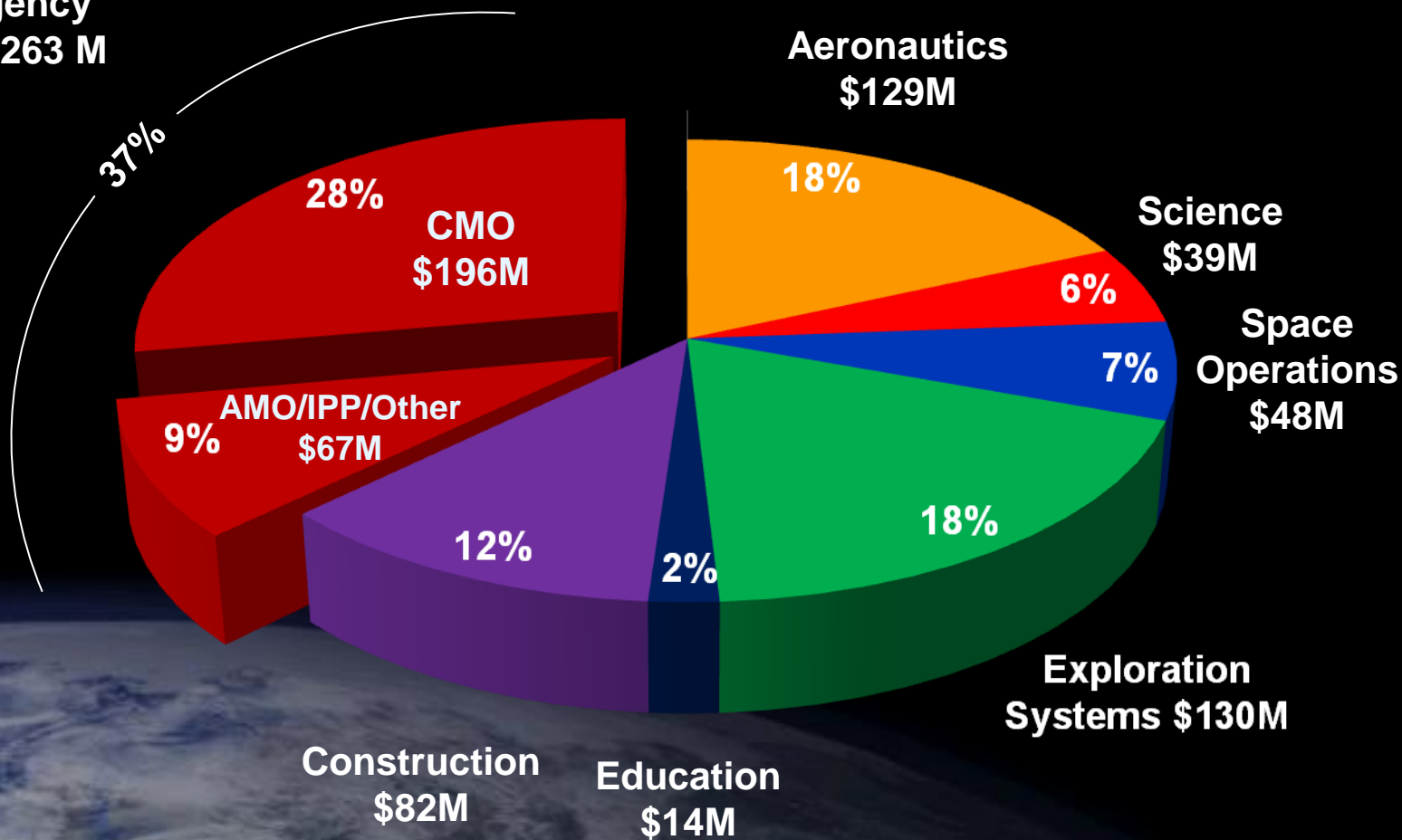
- **Provide world class R&T, revolutionizing aeronautics and space exploration**
- **Advance space missions and aeronautics by leveraging our core competencies to deliver concept-through-flight systems**
- **Deliver program and project management excellence that results in successful missions for our customers and challenging, long-term assignments for continued achievements**
- **Provide excellent institutional capability to enable NASA mission success**
- **Be an integral part of the Ohio community and the Nation**



# GRC 2010 Funding Profile

## Budget \$705M

**Cross Agency  
Support \$263 M**





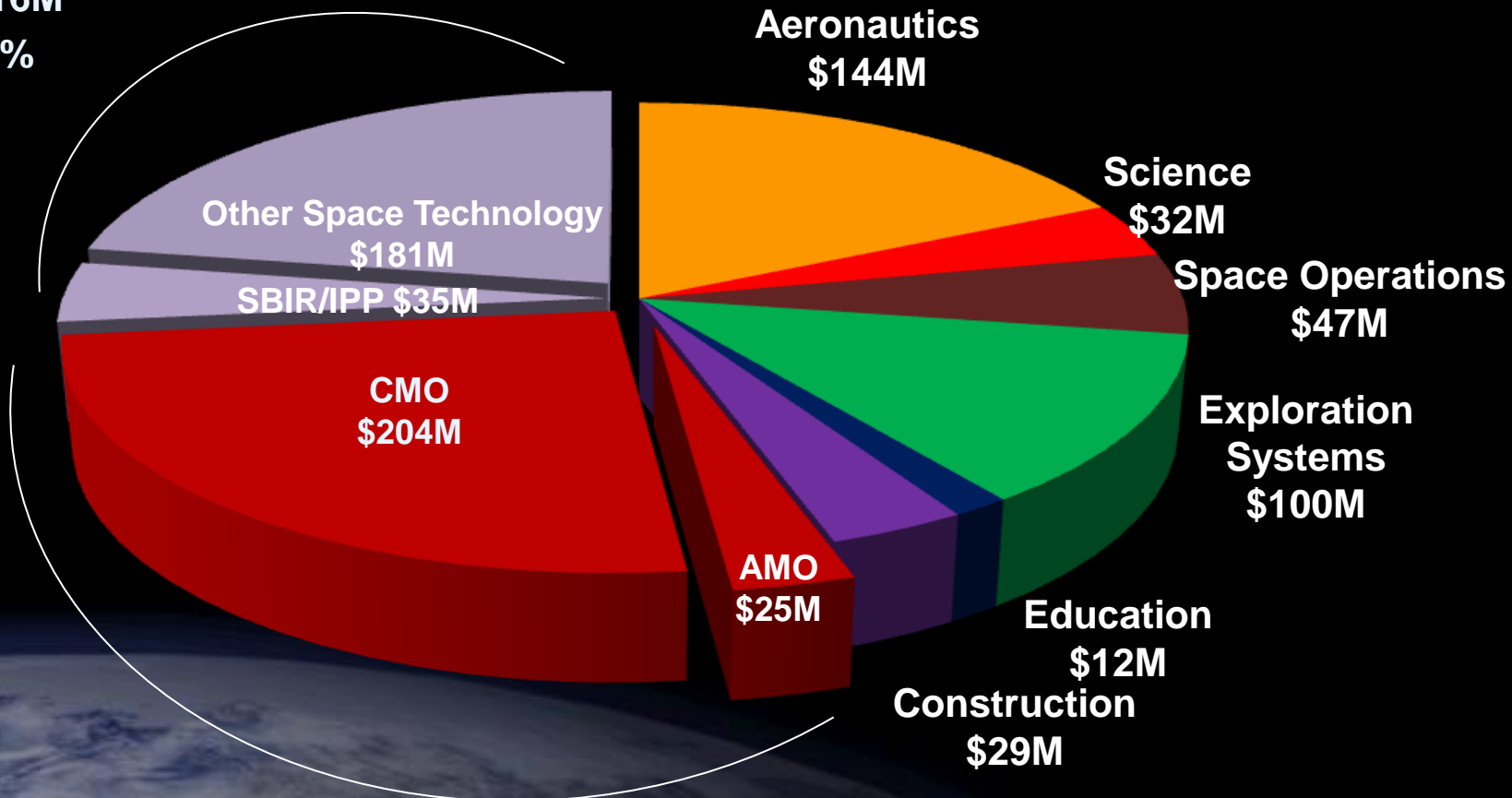
# GRC 2012 President's Budget Request Funding Profile

\$809M

## Space Technology

\$216M

27%



Cross Agency  
Support \$229M

28%

# Civil Service Workforce

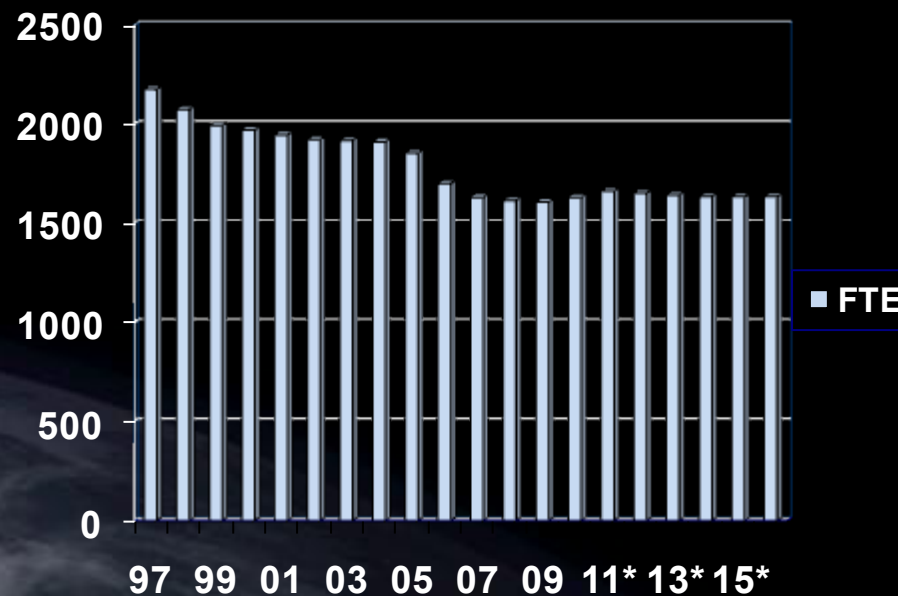
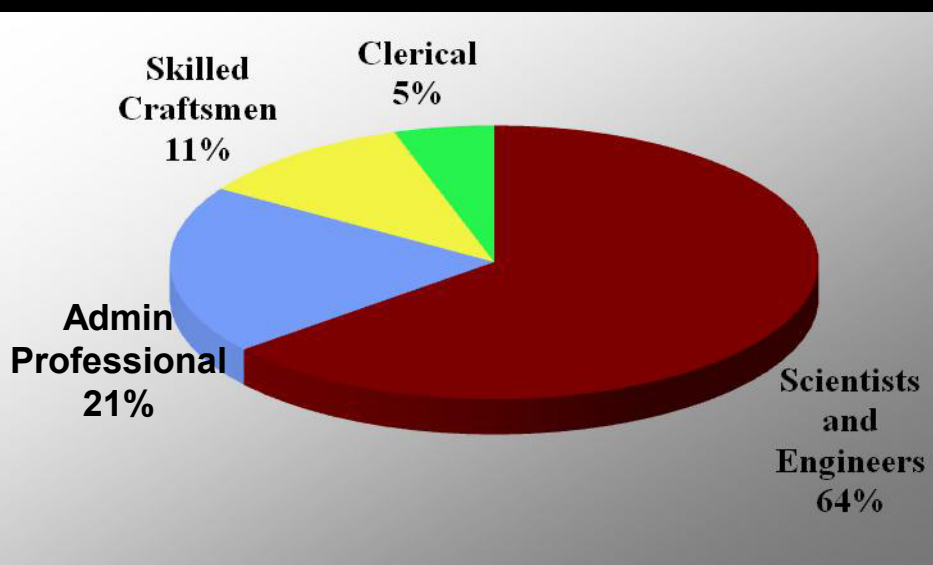
- 66 percent of workforce charges their time directly to the technical mission
- 69 percent of scientists and engineers earned advanced degrees, 25 percent with PhDs



Administrative  
and Clerical

Scientists and  
Engineers

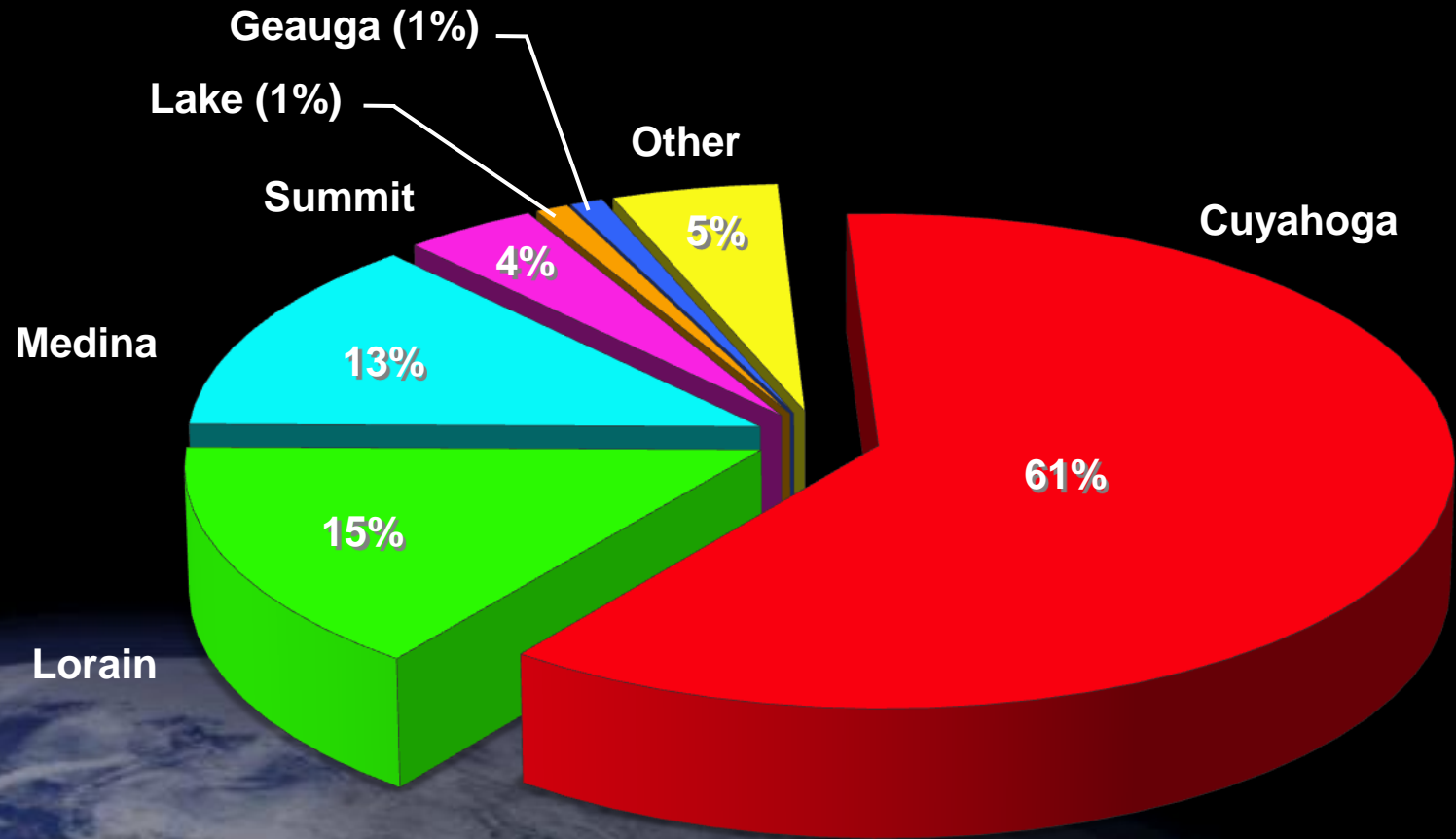
Skilled  
Craftsman



\*Projected Workforce Level



# Glenn Civil Service Employees by County of Residence





## Economic Impact

Impact	Northeast Ohio	State of Ohio
Output	\$ 1.2 Billion	\$1.4 Billion
Value Added	\$ 568.2 Million	\$642.1 Million
Employment	7,017 Jobs	8,293 Jobs
Labor Income	\$344 Million	\$494 Million

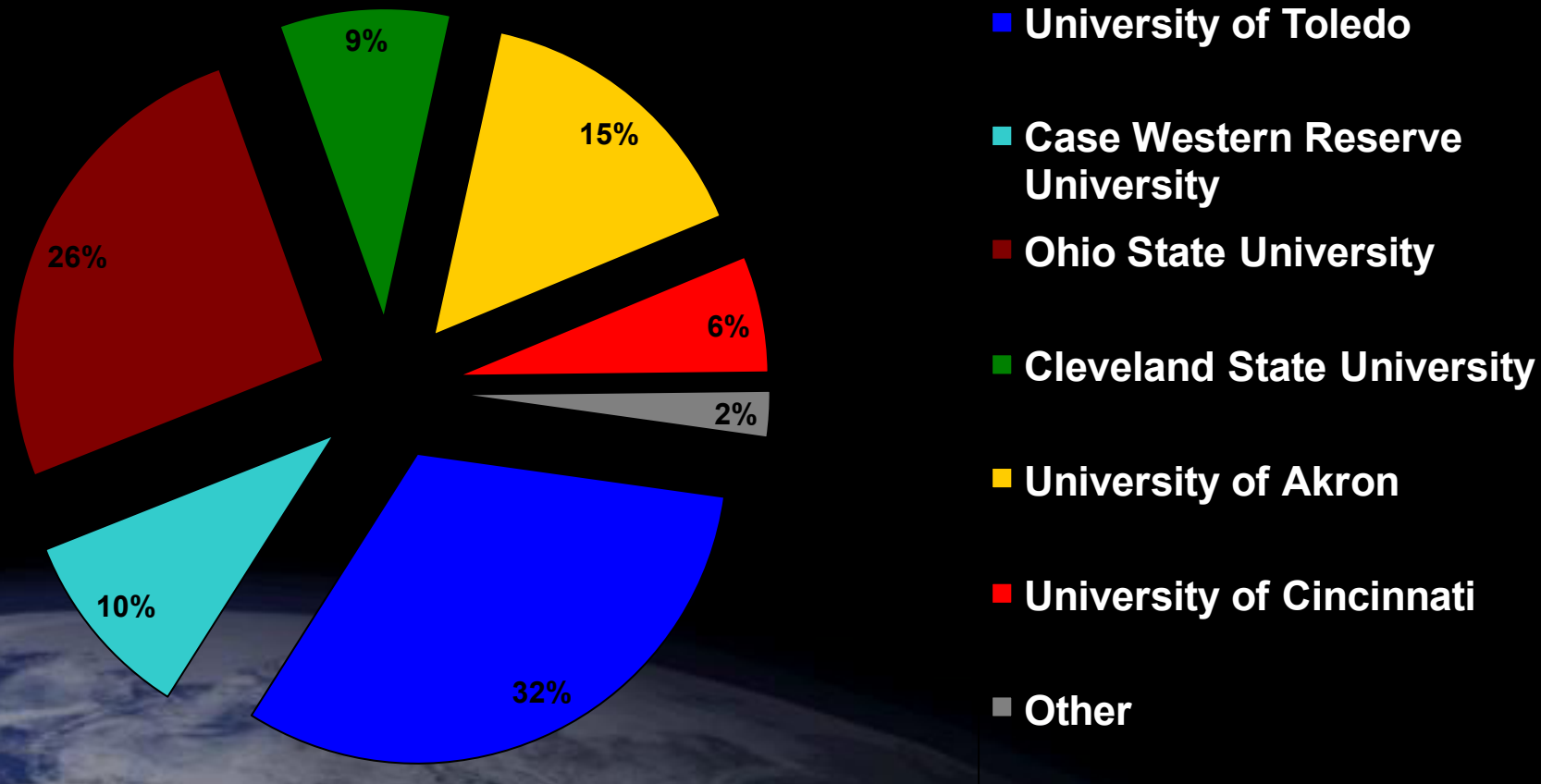
**Employees contribute \$9.4 Million in State and Local Income Taxes**

Note: Data from an Economic Impact Study prepared by Cleveland State University, August 2010



# Educational Grants in Ohio

## \$8 Million (FY 2009)

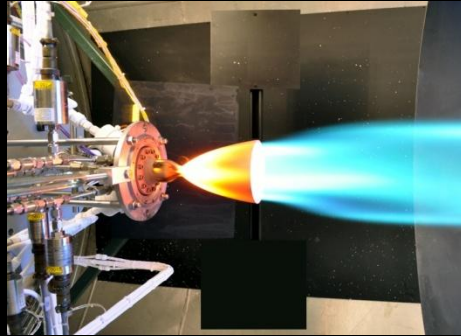


Data from an Economic Impact Study prepared by Cleveland State University, August 2010

# Glenn Core Competencies



**Air-Breathing Propulsion**



**In-Space Propulsion and  
Cryogenic Fluids Management**



**Physical Sciences and  
Biomedical Technologies in Space**



**Communications Technology  
and Development**



**Power, Energy Storage and  
Conversion**



**Materials and Structures  
for Extreme Environments**

# GRC Awards and Recognition



R&D 100 Awards (1966-2010)  
GRC has **109**, highest in  
the Agency in these disciplines:

- Aeropropulsion Systems
- In-Space Propulsion Systems
- Aerospace Communications
- Power and Energy Conversion



Collier Awards for:

- Contributions to Airline Accident Reduction (2008)
- Advance Turboprop Technology (1988)



Emmy Award for  
Communications



Patents:  
**19** GRC patents  
awarded  
FY2009-2010



NASA Software  
of the Year  
Award:

**5** GRC awards  
last 15 years

Presidential Rank  
Awards, 2005-2010:

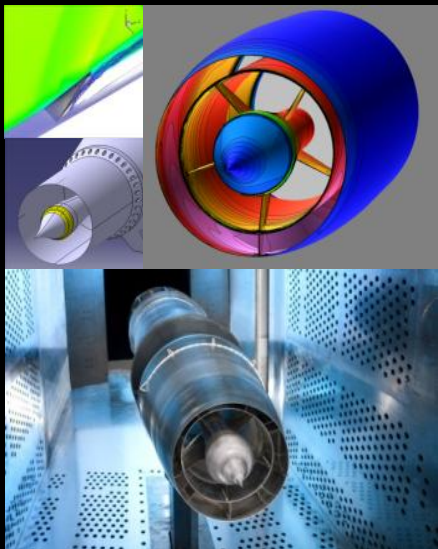
**16** Meritorious  
**4** Distinguished

Space Act  
Awards:

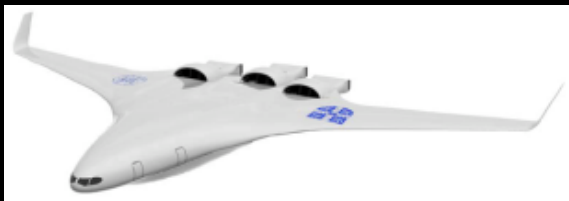
**244** GRC  
awards in  
FY 2010

# Aeronautics Research

## Fundamental Aeronautics



## Integrated Systems Research



## Aviation Safety



## Aeronautics Test Program



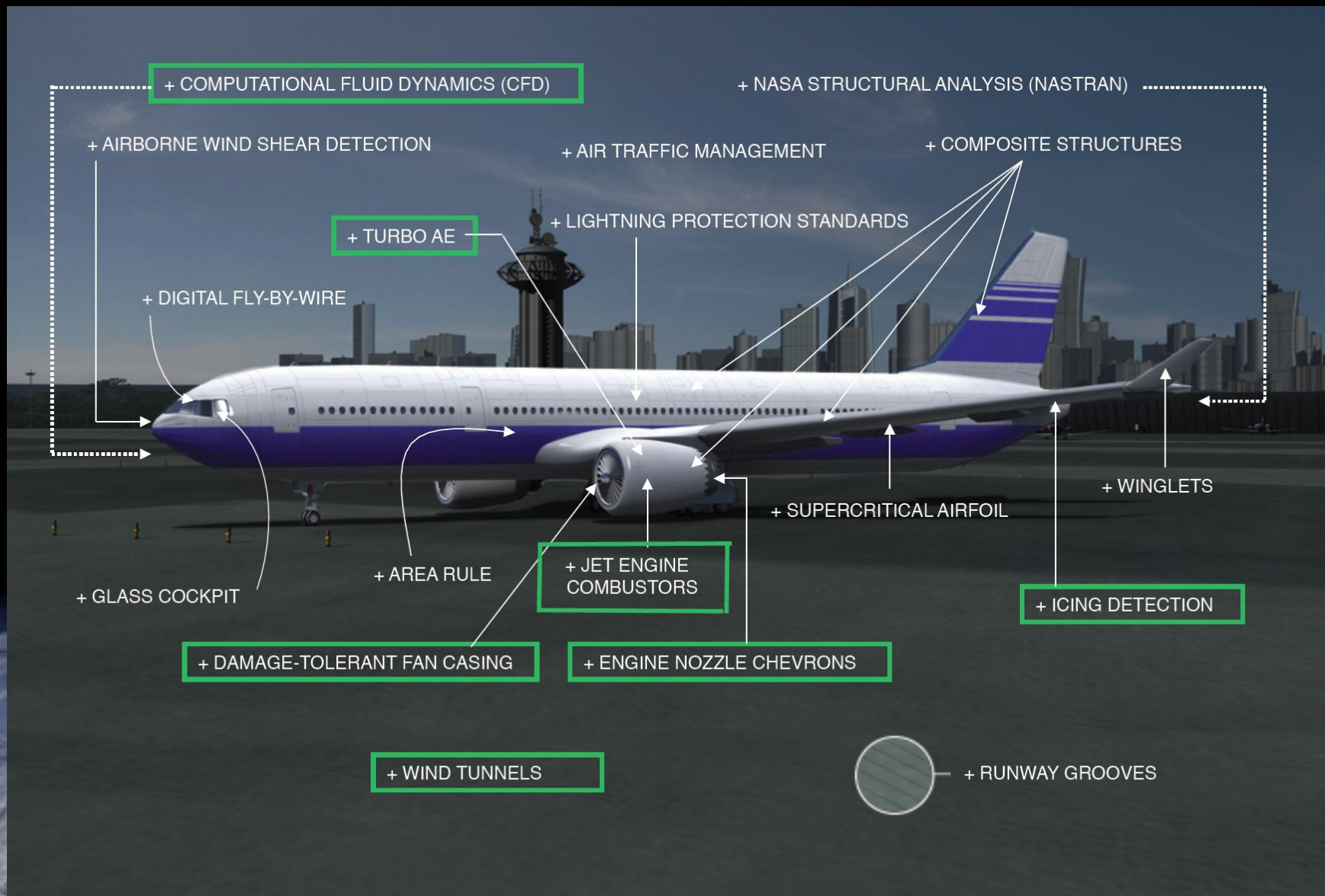
# Aviation's Economic Impact in the U.S.

The aviation industry is vital to the nation's economic well-being

- Aviation directly or indirectly provides 997,000 Americans with jobs
- In 2006, aviation manufacturing and services accounted for \$445B in direct and indirect economic activity
- In 2008, aviation provided the nation with a trade surplus of \$57.4B
- In the U.S., more than 60 certified domestic carriers operate every day
  - They operate more than 6500 aircraft
  - They service almost a million travelers daily on 28,000 flights
  - In 2008, they had an annual operating revenue for commercial flights of \$168B



# Aeronautics Contributions



# Reducing the Environmental Impact of Aviation

## Advance Airframes



## Open Rotor Propulsor



## Geared Turbofan



## Enabling technologies

- Novel architectures for increased lift over drag
- Lightweight structures
- Laminar flow to reduce drag
- Low NO<sub>x</sub> fuel flexible combustors
- Open rotors
- Ultra-high bypass turbofans
- Hybrid-Electric Propulsion
- Novel architectures for shielding airframe noise
- Distributed Propulsion

## Environment Benefit/Goals

- **Fuel burn savings:**  
70% fuel burn reduction (ref B737/CFM56)
- **Emissions reduction:**  
75% less NO<sub>x</sub> (ref CAEP 6)
- **Noise reduction:**  
1/10 the nuisance noise around airports

# Maintaining or Increasing Aviation Safety

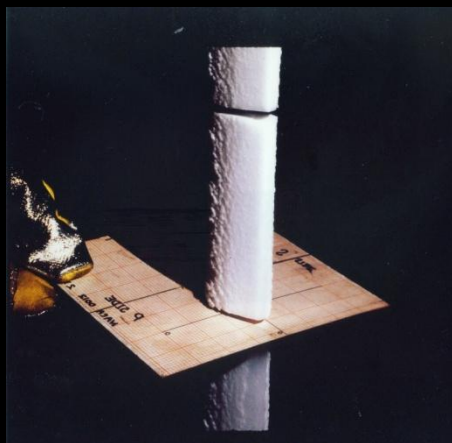
Provides fundamental research of already existing safety challenges and on new and emerging challenges created by the transition to NextGen -- significant increases in air traffic, introduction of new vehicle concepts, continued operation of legacy vehicles, increased reliance on automation, and increased operating complexity.



# Airframe Icing Research at Icing Research Tunnel

## Rime Ice

(occurs at temperatures below  $-10^{\circ}\text{F}$ ; white and opaque; liquid drops freeze on impact)



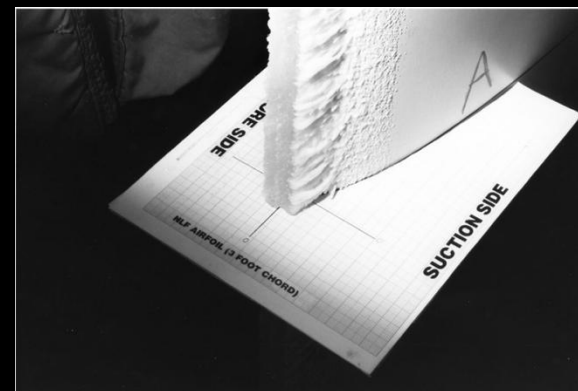
## Glaze Ice

(occurs at temperatures near  $32^{\circ}\text{F}$  and high liquid water contents; clear everywhere; liquid drops do not freeze on impact)



## Mixed Ice

(ice accretion exhibits glaze ice around stagnation line and rime ice away from it; clear near the stagnation line, white and opaque away from it)



## *Icing Research Tunnel Research*

- Fundamental studies of icing physics to improve computational models
  - Safer aircraft designs
  - Basis for aircraft certification
- Used to reduce flight hours for ice detection instrumentation and ice protection systems development and certification



## Scalloped Ice

(3-D and complex ice accretion shape exhibited with highly swept wing configurations)

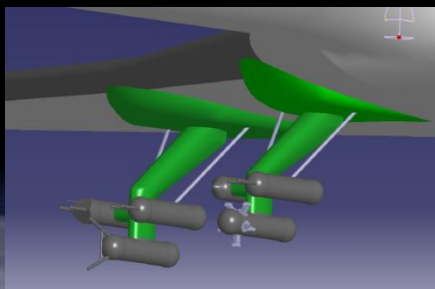
# Aviation Safety- Engine Icing

## Program

A growing aviation safety issue is flight near certain types of storm clouds that can cause ice to build up inside the core of jet engines and cause temporary shutdowns. NASA has established a project that will develop knowledge, tools and approaches that will enable the reduction of turbofan engine interruptions, failures, and damage due to flight in these high ice-crystal content storm clouds.



Artist rendition of the engine icing accumulation and shedding.

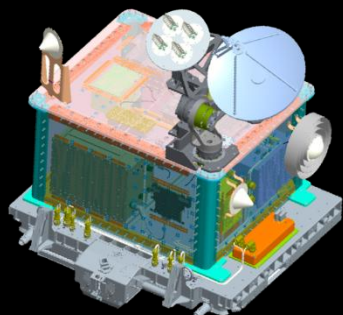


Proposed aircraft instrumentation configuration for weather data gathering of icing environment at high altitudes.



NASA GRC Propulsion System Laboratory to be modified to run engine icing conditions.

# Glenn Current Flight Projects



## CoNNeCT

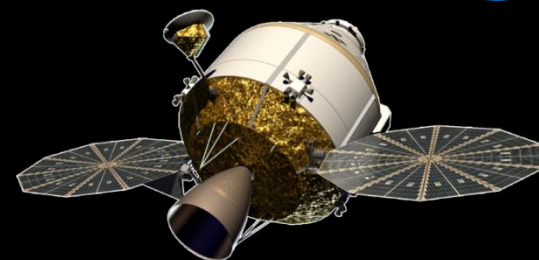
ISS validating key technologies in communications, networking and navigation with reconfigurable Software Defined Radios



## Radioisotope Power Systems (RPS)

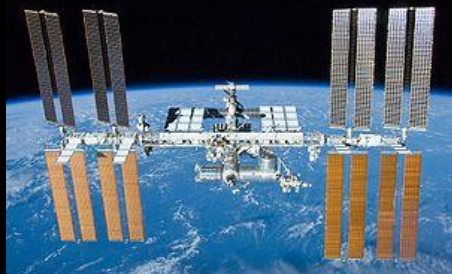
Agency Level Program Office assigned to GRC

Advanced Stirling Radioisotope Generator (ASRG) flight system development



## Crew/Service Module

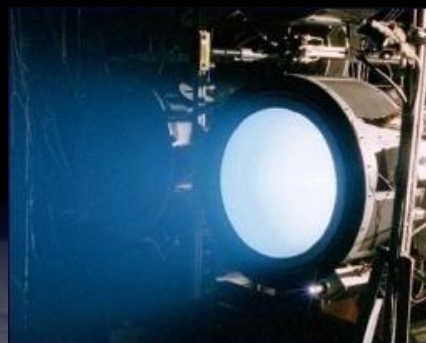
Co-lead with JSC the management of the design, development, verification and certification Crew & Service Module (CSM)



## International Space Station (ISS)

Microgravity Space Experiments: fluid physics, combustion science, and materials experiments

Sustaining engineering for the ISS Electrical Power System



## In-Space Propulsion

NASA Evolutionary Xenon Thruster (NEXT)



## Launch Systems

Support MSFC Heavy Lift Program

Lead payload shroud element, TVC, power, and other vehicle subsystems

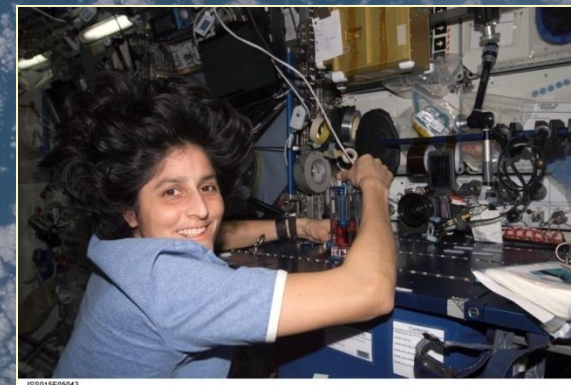
# Shuttle and International Space Station

## Space Shuttle Program

- Engineering and Mission Management Support

## International Space Station (ISS)

- Electrical Power System Sustaining Engineering
- Develop and Operate ISS Experiments
- Support Human Research



# Space Environmental Test Project

## Delivering One-of-a-kind environmental testing capability at ONE location: The Space Power Facility

### The World's Largest Environmental Simulation Chamber Contains:

- **Reverberant Acoustic Test Facility (RATF):** the most powerful reverberant acoustic chamber in the world
  - ✓ Capable of reaching an overall sound pressure level of 163 dB
  - ✓ Can accommodate 32' wide by 60' high test article
- **Largest space simulation vacuum chamber in the world**
  - ✓ 800,000 ft<sup>3</sup> volume, 100 foot diameter, 122 feet high
  - ✓ Features 40 x 40 ft. cryogenic cold wall, and 7 MW power for solar simulation
  - ✓ Electromagnetic Environmental Effects (E3) Reverberant-mode EMI/EMC test capability
- **Highest capacity Mechanical Vibration Facility (MVF) in the world**
  - ✓ 18' diameter test table, expandable to 32'
  - ✓ Test article mass up to 75,000 lbs
  - ✓ Actuators will be used to perform vibration testing in 3 axes expandable to 6DOF





# Science

## Radioisotope Power Systems (RPS) Program



Advanced Stirling Converter

GRC is leading the RPS Program to develop advanced, higher efficiency power systems for NASA missions and spacecraft

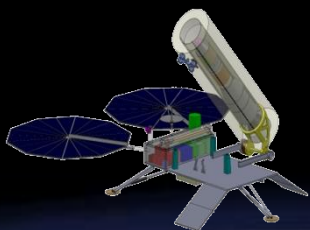


Advanced Stirling Radioisotope Generator (ASRG)

Engineering Unit has accumulated over 14,000 hours of operation

## In-Space Propulsion Project (ISP)

### NASA Evolutionary Xenon Thruster (NEXT)



GRC is running a competitive study on the development of the Mars Ascent Vehicle for the future Mars Sample Return mission



Prototype Model NEXT ion thruster in Performance Acceptance Testing. This test not only verified thruster performance per requirements but also verified manufacturing processes by industry partner Aerojet



Multiple NEXT ion thruster testing demonstrated system level operations with negligible interactions

# Fluids and Combustion Facility (FCF)



*Combustion Integrated Rack (CIR)  
Deployed to ISS on November 14,  
2008*



*Fluids Integrated Rack (FIR)  
Deployed to ISS on August 28, 2009*

- CIR rack is used to conduct fundamental microgravity research in combustion science
- FIR rack is used to conduct fundamental microgravity research in fluid physics
- These racks are 2 of the 4 science racks in the U.S. Lab of the International Space Station

# GRC Exercise Countermeasures Project



- Glenn's Exercise Countermeasures Lab is used to develop effective and reliable low-gravity exercise hardware requirements and validate candidate technologies for long duration crew health

- In collaboration with the Cleveland Clinic

## Glenn Exercise Countermeasures Lab

- A new, more comfortable, exercise harness has been designed by the Glenn-led team for use on the International Space Station

- More comfortable harnessing allows crew members to exercise at higher loading resulting in improved health benefits during treadmill running



## Glenn Harness on International Space Station



# Strategic Partnership Development: Reimbursable Business Pursuit

- **NASA Glenn (GRC) is actively pursuing the development of strategic partnerships with industry, academia, and other government agencies/laboratories.**
- **A prime objective of the strategic partnership building is to provide basis for GRC to aggressively pursue/capture non-NASA business opportunities which utilize Center's competencies (people, facilities, intellectual property) and compliment NASA business which Center executes.**
- **Areas of emphasis for non NASA business pursuit:**
  - **Advanced Energy**
  - **Aerospace Medicine (Bioscience/Bioengineering)**
  - **Homeland Security/Defense**
  - **Non NASA Space Non NASA Aviation**



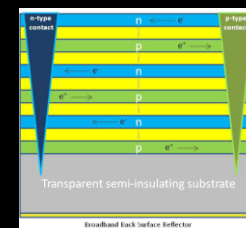
# Strategic Partnership Development: Reimbursable Business Pursuit -- Examples



**DARPA Vulture Program**  
(5 year endurance UAV)



**Testing for DARPA of innovative  
power systems to enable  
highly mobile and  
responsive spacecraft**



**Ultra High Efficiency Solar Cell  
Development (funded by AFRL)**



**Flywheel module designs for terrestrial  
applications through partnership  
with ExEnSo (Minnesota start up company)**



**Open rotor testing in GRC 9 x 15  
Low Speed Wind Tunnel  
(General Electric Aviation)**



**AFRL VAATE Turbine  
Engine Program**



# NASA Glenn Visitor Center Relocated to the Great Lakes Science Center

**We're now where the people are!**

- 330,000 visitors / yr  
(5X previous, onsite location)
- 950 school groups / yr  
(4X previous)
- 75,000 students / yr  
(7X previous)



# Infrastructure Transformation



GMC & B60 Designed  
for LEED Silver



Centralized Office  
Building

*Ground Breaking August 27, 2010*



Lewis Field Main Gate  
*Under Construction*



B142 "KRIS", B14  
Training Center & B15  
Small Dining Room  
Renewal & Relocation



Demolition of the  
Altitude Wind Tunnel  
(AWT)



AWT (1942 – 2008)  
*Nation's first propulsion wind tunnel  
Test Chamber for Project Mercury  
Space Power Chamber for Centaur  
Inactive since 1975*



# Summary

## Center Portfolio

- **Exploration and Aeronautics Research are critical for the current health and future health of Center**
- **Science opportunities continue to be pursued**
- **GRC has relatively small but vital roles in Shuttle and ISS**
- **We continue to provide our unique expertise and capabilities to support operations and Agency Mission Support Functions**
- **We work with businesses and other agencies on a noninterference basis**

## Center Hallmarks

- **Air-breathing propulsion**
- **In-space propulsion and cryogenic fluids management**
- **Power, energy storage and conversion**
- **Advanced communications**
- **Materials and structures for extreme environments**
- **Physical sciences and biomedical technologies in space**

